UNITED STATES MARINE CORPS
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STUDENT HANDOUT

PLAN WATER PURIFICATION/STORAGE SYSTEM

LEARNING OBJECTIVES:

1. Terminal Learning Objectives:

a. Provided a mission, an operating water purification/storage system, operator personnel, and references, direct water purification/storage system operation. The water purification/storage system will be directed to ensure that water is being produced in quantities required to support the number of personnel and facilities per the references. (1169.04.11)

b Provided a mission, a completed Water Reconnaissance Report (DA-1712R), a map of the area, a T/E, T/O, and the reference, plan water purification/storage system. The water purification/storage system will be planned to provide the quantity of water and for the number of personnel and facilities specified per the reference. (1169.04.16)

2. Enabling Learning Objectives:

a. Given an operation order, a camp layout, T/E and T/O, with the aid of references, while conducting a military brief, orally explain the purification/storage system requirements needed to support the operation plan in accordance with TM-08580A-14/1 and TM-09777A-14/1. (1169.04.16a)

b. Given an operation order, a camp layout, T/E and T/O, with the aid of references, list in writing the quantity of purification/storage systems to support the operation plan in accordance with TM-08580A-14/1 and TM-09777A-14/1. (1169.04.16b)

c. Given a water reconnaissance report, with the aid of references, analyze the information provided to support the operation plan in accordance with FM-10-52-1. (1169.04.16c)

d. Given an operation order, a camp layout, T/E and T/O, with the aid of references, list in writing the amount of personnel required to operate the purification/storage systems to support the operation plan in accordance with TM-08580A-14/1 and TM-09777A-14/1. (1169.04.16d)

e. Given an operation order, a camp layout, T/E and T/O, with the aid of references, list in writing the support requirements for the purification/storage systems to support the operation plan in accordance with TM-08580A-14/1 and TM-09777A-14/1. (1169.04.11a)

f. Given an operation order, a camp layout, T/E and T/O, with the aid of references, list in writing the safety precautions required for purification/storage systems to support the operation plan in accordance with TM-08580A-14/1 and TM-09777A-14/1. (1169.4.11b)

g. Given an operation order, a camp layout, T/E and T/O, with the aid of references, list in writing the task requirements for the purification/storage systems to support the operation plan in accordance with TM-08580A-14/1 and TM-09777A-14/1. (1169.4.11c)

BODY

1. Conducting a Water Analysis:

a. Water Requirements:

(1) Water support planning is a continuos process that begins with identifying the size of the force to be supported. Daily water requirements vary with a number of factors including the season of the year and tactical situation. Dehydration can occur quickly in both hot and cold climates if personnel don't drink plenty of water. Below are computations to determine supply, purification, and storage requirements for water.

(a) Water Consumption Factor: Water requirements are based on 20 gallons of water per man a day. This is based on personnel in arid environments, less water is required in temperate zones. These requirements include a usage factor for drinking, hygiene, food preparation, vehicle, medical(heat treatment/ice water), graves, laundry, construction, air craft and 10% for waste/evaporation is included.

(b) Supply Requirements: Multiply the actual strength by the proper consumption factor. The total is expressed as gallon per day.

(c) Water purification Requirements: Divide the total daily requirements by the daily production capability of one purification unit. Water purification equipment is operated twenty hours per day under normal conditions.

(d) Storage Requirements: Is based on re-supply times and daily requirements.

b. Water Reconnaissance:

(1) The purpose of a water reconnaissance is to gather information about water sources for it's possible use and development. There are two types of reconnaissance:

(a) Air reconnaissance - may be utilized if aircraft are available. An air reconnaissance is generally a reliable means for rapidly securing information about water sources over a large area.

1 If a helicopter is used, air and ground reconnaissance can be conducted as one.

2 The use of aircraft for reconnaissance is limited by adverse weather conditions and security conditions.

(b) Ground reconnaissance - is the only positive way of gathering accurate information from which to select a water point. The factors to be considered during the ground reconnaissance are:

1 Water Quantity - know the projected water requirements to support the operation. Use the formula for determining the quantity of water available from a source.

2 Water Quality - should be of such quality that it can be approved by medical personnel as meeting raw water standards and at the same time be readily purified with available water purification equipment.

3 Accessibility - the area must be accessible to vehicles and personnel. It should have good road nets with turnarounds, cover and concealment at the water source, and an adequate staging area. The roads should be able to withstand, under all conditions, the heaviest of vehicles.

4 Site conditions - consider drainage, security, and adequacy of the bivouac area in that order of importance.

a Drainage - the site must be on high, porous ground.

b Security - the site should provide cover and concealment with security against ground attack and sabotage.

c Bivouac - must be at least 100 feet downstream from the water purification operations. It should also be located near the water point to ensure personnel availability for work or emergencies.

(2) Responsibilities

(a) Unit Commander - is responsible to make sure that Marines have an adequate amount of water for all purposes.

(b) S-4 (logistics) - coordinates reconnaissance activities with the S-2 (intelligence).

(c) Utilities Chief - is tasked with locating the water sources.

(d) Medical department - inspects the water quality and makes recommendations for improvements to the water point.

c. Performing a Total Dissolved Solids Test:

(1) The purpose of performing a total dissolved solids (TDS) test is to determine if the water is fresh, brackish, or salt. The TDS meter measures how much electric current can flow through a sample of water and registers the reading on a scale in parts per million **(ppm)**. Water sources are identified according to the categories listed below:

(a) **Fresh - 0 ppm - 1500 ppm**

(b) **Brackish - 1501 ppm - 15,000 ppm**

(c) **Salt - 15,001 ppm - Above**

NOTE: Parts per million is a ratio by weight of parts of a substance in one million parts of water.

(2) Open case and carefully remove equipment and supplies as needed. Note location for re-packing.

(3) Calibrate the TDS meter

(a) With meter off, adjust pointer to zero by turning meter zero adjust screw.

(b) Remove bottom cover by carefully prying it off TDS meter and install a battery or DC adapter if available. Be sure the battery removal clip is in place prior to installing battery. Check battery condition.

1 Adjust range switch to "S" position.

2 Press button and adjust the master calibration control to the maximum. Pointer must indicate full scale or above. If not, replace battery.

3 Press button and adjust master calibration control until the meter reading matches the internal value on label attached to bottom cover.

(4) Calibrate the range extender as follows:

(a) Fill the cell cup with standard solution to ¼ inch above upper electrode.

(b) Position range switch to 1000.

(c) Rinse the range extender in standard solution 442-30,000. Discard the solution.

(d) Fill the cell cup with the standard solution 442-30,00 and insert the range extender, seating the O-ring seal.

NOTE: RANGE EXTENDER IS ADJUSTED TO CORRECT METER READING. DO NOT ADJUST INTERNAL CALIBRATION CONTROLS.

(e) Press button. Pointer should be at 3 plus or minus 0.1 on the scale, if not, adjust range extender as follows:

1 Remove range extender from cell cup.

2 If reading was too high, push or tap white insert into the range extender body.

3 If reading was too low, twist and pull white insert out of the range extender body.

4 Insert the range extender into the cell cup, seating O-ring seal.

5 Press the button. The pointer should be at 3 plus or minus 0.1 on scale, if not, repeat steps **1-5**.

6 Discard solution and flush the cell cup and range extender with de-mineralized or distilled water. Discard wash water and thoroughly dry cell cup.

(5) Operate the TDS meter

(a) Turn the range switch to “S” position.

(b) Press button and compare meter reading with the internal standard value on label attached to bottom cover. If reading is different, remove bottom cover and adjust the master calibration control until it matches.

(c) Turn the range switch to 1000.

(d) Rinse the cell cup three times with water to be tested.

CAUTION: DO NOT DIP THE METER INTO THE WATER BEING TESTED TO FILL CELL CUP. DAMAGE TO METER CAN RESULT.

(e) Fill the cell cup with water to be tested to at least ¼ inch (6mm) above the upper electrode.

(f) Press the button.

1 If the pointer is below 0.5 on the scale, adjust the range switch to 100. If pointer is still below 0.5 on the scale, adjust range switch to 10.

2 If the pointer goes off the 0.5 scale, to the right on the 1000 range, use the range extender which will increase the range 10 times.

a Rinse the range extender three times with the water tested, discarding between rinses.

b Push the range extender into the filled cell cup, seating the O-ring seal.

c Press the button and adjust the range switch as indicated in step (6).

3 If the pointer goes off the scale to the right on the 1000 range setting, the meter must be adjusted for range doubling as follows.

a Discard water in cell cup.

b Rinse cell cup with de-mineralized water and dry thoroughly.

c Remove bottom cover and adjust range switch to "S" position.

d Press button and adjust master calibration control until pointer reaches half the internal standard value on label attached to bottom cover.

e Attach bottom cover and retest the water.

4 To determine Total Dissolved Solids in Parts Per Million, multiply pointer reading range setting of the range switch.

EXAMPLE: IF THE POINTER READING IS 3 AND THE RANGE SWITCH WAS SET AT 10, MULTIPLY 3 X 10 = 30 PARTS PER MILLION. IF THE RANGE SETTING WAS SET AT 100, MULTIPLY 3 X 100 = 300 PPM. IF THE RANGE SETTING WAS SET AT 1000, MULTIPLY, 3 X 1000 = 3000 PPM.

5 To determine Total Dissolved Solids in Parts Per Million, If the meter was adjusted for doubling, multiply the answer by 2.

6 Remove range extender if used, and empty cell cup.

7 Thoroughly rinse cell cup, collection bottle, and any equipment used with de-mineralized water. Dry thoroughly with paper towels after rinsing and repack meter.

8 If the meter was adjusted for range doubling, readjust for standard range.

d. Performing a pH Test Using The Color Comparator:

(1) The purpose of performing a pH test is to measure the amount of acid or alkalinity in water. pH stands for “potential of electricity for positive ions”. pH measures the quantity of free hydrogen ions which are the foundation for all acids that are present in a known liquid. The color comparator uses chemicals that changes color when add to the water being tested.

(2) pH is based on a scale ranging from 0 which is the maximum acidity, to 14 which is the maximum alkalinity. 7.0 on the scale indicates neutral water. Acid and alkaline are balanced at this point on the scale, but this does not mean that water is free from germs.

(3) Perform pH test:

(a) Unlatch and open carrying case cover. Remove comparator housing and eyepiece. Fit eyepiece onto housing.

(b) Remove pH color disc and insert into housing. Numbers must be visible through indicator window.

(c) Rinse two comparator cells three times with water being tested.

(d) Fill two comparator cells to the 15ml mark with the water to be tested and insert in housing..

(e) Fill the dropper with wide range indicator solution to the 0.50ml mark.

(f) Add the wide range indicator solution from the dropper to the comparator cell on the left. Use sufficient force to mix.

(g) Hold the comparator housing up and look through the eyepiece. Face a good light source. Be sure your fingers do not cover the light window in the back of the comparator housing. Rotate the color disc until a color on the disc matches the color comparator housing. If color falls between readings, estimate.

(h) Remove comparator cells from comparator housing and discard water samples and solution. Thoroughly rinse all equipment with de-mineralized water or distilled water.

e. Performing a Chlorine Residual Test:

(1) Chlorine is the disinfectant agent usually specified for military use. Presently, this is the only widely accepted agent that can destroy organisms in water and leaves an easily detectable residual that serves as a tracer element.

(2) Sudden disappearance of chlorine residual signals potential contamination in the system. No other available disinfectant is as acceptable or adaptable for potable water treatment operations as chlorine.

(3) Perform a chlorine residual:

(a) Remove Chlorine color disc and insert into housing. Numbers must be visible through indicator window.

(b) Rinse two comparator cells three times with water being tested.

(c) Fill two comparator cells to the 15ml mark with the water to be tested and insert in housing.

(d) Add two DPD no. 1 chlorine tablets to the comparator cell on the left. Crush tablets with a plastic rod until dissolved.

NOTE: DPD NO. 1 CHLORINE TABLETS ARE IRRITATING TO THE EYES, RESPIRATORY TRACT, AND MAY CAUSE ALLERGIC SKIN REACTION. PROVIDE VENTILATION WHEN HANDLING AND WEAR SAFETY GLASSES AND GLOVES.

(e) Hold the comparator housing up and look through the eyepiece. Face a good light source. Be sure your fingers do not cover the light window in the back of the comparator housing. Rotate the color disc until a color on the disc matches the color comparator housing. If color falls between readings, estimate.

(f) Remove comparator cells from comparator housing and discard water samples and solution. Thoroughly rinse all equipment with de-mineralized water or distilled water.

(g) Remove eyepiece and color disc from housing and carefully pack all equipment back into carrying case. Close latch and cover.

f. Water Reconnaissance Report:

(1) Field reports are the most important and reliable source of information. The S-2 section may provide information which has

been gathered from local inhabitants or from interrogation of prisoners of war.

(2) Map studies should be taken into consideration. Aerial photos, if available, should be studied before conducting the actual ground reconnaissance. The information obtained from maps are:

(a) Type of source - Indicate if the source is a stream, river, pond, lake, ocean, or natural well.

(b) Roads/Road nets - Description of roads in and out of the water point, such as dirt, gravel, or paved.

(c) Terrain - Give general description such as flat, level, hilly, or rolling ground.

(d) Security - Indicate the type of security required for the water point.

(3) The water reconnaissance report is used to keep track of the data gathered on the water recon by the unit leader. It also shows what the different types of water sources can provide and what the requirements are for development. The water reconnaissance report contains all the following information:

(a) Heading - The heading is where all the information such as; who, what, where, when, etc. is annotated.

1 Date - The date the water reconnaissance was performed.

2 Time of reconnaissance - Must be given for accurate records to be kept.

3 Reported by - This block should contain the name of the person performing the reconnaissance.

4 Forwarded to - This is who the report is being sent to.

5 Map Coordinates - The six-digit grid coordinates of the location should be given.

(b) Quality/Quantity:

1 Type of source - Indicate if the source is a stream, river, pond, lake, ocean, or natural well.

2 TDS - The measure of total dissolved solids present in the source.

3 Temperature - The temperature of the water in ^{0}F.

4 Turbidity - The amount of suspended solids in the water. Turbidity is put into three categories:

a Light

b Medium

c Heavy

5 pH Test - Note the measure of acidity or alkalinity in the water.

6 Chlorine test - Note the measure of chlorine in water.

7 Quantity - Indicate the yield of the source in gallons per minute or as an infinite source.

(c) Site Conditions:

1 Security - Indicate the type of security required for the water point.

2 Drainage/Soil type - List if natural run-off is provided or if drainage must be dug. Also indicate if the soil type is frozen, stable, rocky, or clay.

3 Terrain - Give general description such as flat, level, hilly, or rolling ground.

4 Bivouac - Identify the size of the area available for bivouac. It should be located 100 yards away and 100 feet downstream from the source.

5 Distance to consumer - In most cases this should not exceed a radius of ten miles.

6 Roads - Description of roads in and out of the water point, such as dirt, gravel, or paved.

(d) A sketch of the area should be made during the ground reconnaissance and keyed to a map. Detailed information gathered on potential sites can be invaluable and is of great importance. Ensure the direction of north is placed on all sketches by using the north indicator symbol.

2. Developing a water source: The purpose for developing a water source is to increase the quantity of water, improve its quality, or make it more readily available for treatment and distribution. Some of the equipment needed is listed below:

a. Intake Hoses: Several considerations should be taken in the development of intake points. All intake hoses or pipes should have a strainer or suction screen regardless of the clarity of the water. The strainer must be at least 4 inches below the water level and protected against floating debris.

b. Pumps: The practical limit of suction lift of raw water pumps issued with water purification equipment is 25 feet at sea level. Suction lift decreases at higher altitudes. Because pumps must create a partial vacuum in the suction line, the raw water intake hose must be airtight for the pump to work.

c. Development of inland surface water sources:

(1) There are a number of development considerations and techniques which apply to inland types of water sources. They are discussed below:

(a) Surface water sources are the most accessible type, in that the source lends itself readily to the purification equipment common to engineer units. The methods of constructing intake points for surface water sources are:

1 Rocks and stakes:

a If the water source is not too swift and the water is sufficiently deep, prepare an expedient intake by placing the strainer on a rock. This will prevent clogging of the strainer by the silt normally found at the bottom of the stream bed.

b If the water source is a small stream or shallow lake, secure the intake hose to a post or stack.

c These two methods will prevent the strainer from becoming clogged by the silt normally found at the bottom of the waterbed and providing enough water overhead to prevent the suction of air into the intake hose.

2 Pits:

a When the water source is so shallow that the intake strainer is not covered by at least four inches of water, but the source must be used, a pit should be dug and the strainer laid on a rock or board placed at the bottom of the pit.

b Line pits that are dug in streams with clay or silt bottoms, with gravel to prevent dirt from entering the purification equipment. Surround the strainer with gravel to prevent collapsing of the sides of the pit and also to shield the strainer from damage by large floating debris.

c A similar method, by enclosing the strainer in a bucket may also be used.

3 Dams:

a Dams are used to raise the level of water in small streams to cover the intake strainer.

b In swift flowing streams, construct a wing or baffle to protect the intake strainer without collecting water. To construct dams the following material can be used: logs, perforated wood, dirt, concrete, steel, sand bags, or any natural material

c These materials should be placed at the narrow part of the stream having stable banks.

4 Floats:

a Floats are used to keep the suction hose off the bottom of the water source in large streams where the quantity of water varies across its width or where water is not deep enough near the banks to cover the suction strainer.

b Cover the hose and strainer with a minimum of water four inches of water, by anchoring or stationing the float at the deepest part of the stream.

c Secure the intake hose to the float, allow enough slack for movement of the float. An anchor support line should be attached and have adequate slack to allow the suction strainer to remain under water at all times if there is any changes in the water level.

d Floats may be constructed from the following: empty drums, logs and lumber, or sealed cans.

5 Galleries: The quality of water may be improved from a muddy or extremely turbid water source by digging intake galleries along the bank. To construct a gallery perform the following:

a Dig a trench along the bank of the water source. The trench must be deep enough to allow water from the source to seep into it and to intercept ground water flowing toward the stream.

b Then fill the trench with gravel to keep the sides from collapsing.

c Then place the intake hose with strainer in the gravel below the waterline.

NOTE: A GALLERY REQUIRES A LOT OF WORK, BUT IT MAY BE WORTH IT. IT REDUCES THE AMOUNT OF CHEMICALS NEEDED FOR COAGULATION, EXTENDS THE

LIFE OF FILTER CARTRIDGES, AND EXTENDS THE FILTER RUN BETWEEN BACKWASHING.

d. Development of ground water sources:

(1) When surface water supplies are inadequate or unusable, develop ground water supplies. Ground water is available below the earth's surface in most regions of the world. The depth depends largely on the type of rocks and soil, the amount of rainwater, and the topography of the land. The following types are listed below:

(a) Aquifers - is a layer of rock below the water table from which you obtain water. It is sometimes referred to as a water-bearing formation or water-bearing stratum. Aquifers can be found in almost any area.

(b) Springs - is water which emerges at the surface naturally with a distinct current. When a distinct current is not present, the flow is called a seep. Most springs and seeps represent water from rain or snow on some near by higher ground which moves underground to where it comes up out of the ground. Its underground course depends on the type of soil it moves through. There are different types of springs.

1 Artesian springs - are springs where water bubbles up with a measurable force, indicating that it is under pressure.

2 Thermal springs - are any springs having a temperature higher than the yearly average temperature for a given region.

3 Gravity springs - are those in which subsurface water flows by gravity from a high point of intake to a lower point of issue. The two most important types are:

a Water table springs and seeps - occurs where the water table comes near or intersects the surface of the ground. These springs can be normally found around the margin of depressions, along the slope of valleys, and the foot of an alluvial fans.

b Contact springs and seeps - occur along an exposed contact point, like along hillside. These springs appear along slopes but may be found at almost any elevation, depending on the position of the rock formation.

4 Development of springs:

a Enlarge the oulet of the spring by building a dam and guiding the water to storage.

b To reduce possible pollution, clear a spring of all debris, undergrowth, top soil, loose rocks, and sand.

c Improve springs by building collection boxes or digging ditches and tunnels. Collection boxes or basins can be made of wood, tile, or concrete. They collect water which flows from rocks under the force of gravity. The box should be large enough to hold most of the flow.

d Place the box below ground level so that only the top is slightly above the surface. Tightly cover the box to prevent contamination and decrease evaporation.

e Design the inlet to keep out surface drainage and prevent pollution. Fence the area and provide proper drainage.

f A screen on the overflow pipe keeps out insects and small animals. A strainer on the intake pipe or hose will keep large suspended particles from being taken by the raw water pump.

g To get water from a seep or contact spring, dig deep, narrow ditches leading from the spring to the collection point. Large - diameter pipe is more suitable for this purpose.

(c) Artesian well - are wells that has been drilled into an aquifer.

NOTE: IF SUCH A WELL, HAD ENOUGH PRESSURE TO BRING THE WATER ABOVE THE GROUND SURFACE, IT IS CALLED A FLOWING ARTESIAN WELL; IF THE WATER RISES ONLY TO AN INTERMEDIATE LEVEL, IT IS A NONFLOWING ARTESIAN WELL. WHENEVER A NATURAL OUTLET OCCURS IN AN ARTESIAN AQUIFER, AN ARTESIAN SPRING IS FORMED.

(d) Man Made Wells - wells are classified into five types, according to their method of construction. The five types are:

1 Dug - a dug well is one in which the excavation is made by the use of picks, shovels, spades, or digging equipment, such as sand buckets or clamshell buckets.

2 Bored - a bored well is one in which the excavation is made by the use of hand or power augers.

3 Driven - a driven well is constructed by driving a pointed screen, referred to as a drive point, into the ground. Casings or lengths of pipe are attached to the drive point as it is being driven into the ground.

4 Jetted - a jetted well is one in which the excavation is made by the use of a high velocity jet of water. However, in some regions of the Arctic, steam is used for jetting instead of water.

5 Drilled - a drilled well is one in which the excavation is made by either percussion or rotary drills. The

excavated material is brought to the surface by means of a boiler, sand pump, suction bucket, hollow drill tool, or hydraulic pressure.

6 Hydraulics of wells: Before a well is pumped, the water level is the same as the level of the surrounding water table. Measure the depth from the ground surface to the water level. The following definitions apply to hydraulics of wells.

a Static level - the depth from the ground surface to the water level. Thus if the water in a well is 25 feet below ground level, the static water level is 25 feet.

b Pumping level - when a well is pumped, the static water level drops. After several hours of pumping at a constant rate, it stabilizes in a lower position. This is called the pumping level or dynamic water level for this rate of pumping.

e. Development of seawater sources:

(1) When development of inland or ground water sources are not available, the development of seawater sources may become necessary. Some of the factors to be considered in developing seawater sources are:

(a) Surf action

(b) Saltwater corrosion

(c) Living organisms

(d) Surface oil along beaches

(e) Suspended sand and silt

(f) The rise and fall of water level with the tide

(2) Saltwater Wells: Beach wells are preferred to offshore intakes. Wells can be dug to tap brackish or salt ground water. This eliminates the problems caused by tides, surf, and shallow water close to the shore. A disadvantage is the possibility of hydrogen sulfides in the raw water, causing fouling problems with RO membranes and taste and odor problem in drinking water.

(3) Offshore Intakes: Offshore intakes are sometimes required due to lack of time, personnel, or equipment needed to develop beach wells. Also, coral formation sometimes prevents construction of wells. You can use intakes of either the rigid pipe or float type. If possible, locate it in deep water beyond the surf action in a vertical position.

3. Reverse Osmosis Water Purification Unit (ROWPU):

a. Osmosis is the spontaneous flow of a liquid of low

concentration through a semi-permeable membrane, a material that only certain molecules can readily pass, into a solution of higher concentration that tends to equalize the levels on both sides of the membrane. The process of both sides equalizing is referred to as the osmotic effect. Reverse Osmosis is water flowing at high pressure, through a semi-permeable membrane in the opposite direction from Osmosis. The result is water with a high concentration to water with a low concentration of molecules other than water.

b. The Reverse Osmosis Water Purification Unit (ROWPU) is a skid mounted, mobile, or air transportable unit capable of purifying fresh, brackish, and salt water at a rate of 600 gallons per hour.

c. The unit is configured in a frame that measures 5.6′ H x 6.9′ W x 9.5′ L, weighs approximately 7300 lbs

d. The unit requires a 22 kilowatt power source.

e. The unit is designed to operate for 20 continuous hours a day.

f. The unit consists of the following components:

(1) Raw Water Pump: Water is delivered to the unit by the raw water pump. There are two raw water pumps and they are both:

(a) Centrifugal

(b) Self-priming after the initial prime

(c) Rated at 30 gpm with a 105 ft. head

(d) Powered by 2 HP electric motor

(2) Multimedia Filter: When the raw water enters the ROWPU it goes through its first cycle of filtration in the multimedia filter. Water enters the filter through the top inlet pipe and passes through various layers of media to the bottom of the filter. Once on the bottom, the partially purified water enters the perforated pipes and exits the outlet pipe on the bottom of the filter. The media consists of: 3" of garnet, 12" of filtered sand, 15" of coal and 2" of plastic material weighing 805 lbs which sits on top of 425 lbs of bedding. The bedding consist of gravel: fine through medium grades.

(3) Booster Pump: The booster pump transfers the water from the multimedia filter to the cartridge filter. In doing so, it equalizes the flow of water pressure through the multimedia filter. The pump is:

(a) Centrifugal

(b) Rated at 30 gpm with a 50 ft. head

(c) Powered by a 1 HP electric motor

(4) Cartridge Filter: The cartridge filter consists of an upper and lower compartment. The upper compartment houses eight 40 inch long disposable fiber cartridges that provide a secondary stage of filtration by removing any suspended matter in the water missed by the multimedia filter. This filtered water is then collected in the lower compartment where it will be suctioned by the R.O. pump.

(5) R.O. Pump: Picks up the water from the lower compartment of the cartridge filter and pressurizes it. The R.O. pump is a high pressure pump with:

(a) Positive displacement plungers (5 pistons); 3 pistons on the Charlie Model.

(b) Rated at 51 gpm with a 980 psi head.

(c) Driven by five V-belts from a 20 HP electric motor which turns counterclockwise.

NOTE: The R.O. pump has adjustable low pressure and high pressure switches, located behind the control panel that activates when the R.O. pump has less than 10 psi inlet pressure or discharge pressure exceeds 1250 psi. When activated, either switch will shut off the R.O. pump.

(6) Pulse Dampener: The R.O. pump pushes the water through the pulse dampener which reduces pulsation in the water caused by the pistons of R.O. pump. There are (4) baffles inside the pulse dampener designed to reduce shock. From the pulse dampener, the water exits the vent vessel line (a bypass to the R.O. vessels) until the vent vessels valve is closed. Once closed, the water is then redirected to the R.O. vessels.

(7) R.O. Vessels: There are four R.O. vessels, each housing two R.O. elements. These elements are joined in the middle by an inter-connector (plastic couplings). There are also end connectors that join the end caps to the outside of the elements.

(8) R.O. Elements (Spiral Wound): When water enters the R.O. vessels, it is then on it's final stage of filtration. Each element has a brine seal that opens up against the water flow channeling the water through the R.O. element. As the water enters the elements, it works its way down the spiral membranes where molecule separation occurs. In it's final stage the water enters the product water tube located in the center and exits the unit as product water. The remaining feed fluid (brine) continues to flow through the other end of the element then enters the next element until the process repeats itself through all eight elements. It then leaves the R.O. vessels as brine water. These elements are designed to reject a minimum of 98.5%

of salt from the water and about 99% of all organic materials in the water. The two types of elements used are Filmtec and Fluid Systems.

NOTE: Chlorine will destroy membranes in the R.O. elements rendering the R.O. elements unserviceable.

(9) Distribution Pump: The product water is distributed from the product water tank by using a distribution pump. It is rated at 30 GPM.

(10) Backwash Pump: The Backwash Pump is rated at 120 GPM and is used to backwash the multimedia filter. A strainer assembly is attached to the discharge end of the pump to filter out any particles in the backwash tank.

(11) Chemical Feed Pump: The R.O. unit uses several chemicals to aid in production of water. There are four chemical feed pumps each rated at 3.17 gals/hr and powered by a 1/3 HP electric motor. They are:

(a) Chlorine Feed Pump: Feeds diluted chlorine to product water to kill bacteria so that water in storage tanks remain potable.

(b) Polymer Feed Pump: Feeds diluted polymer (polyelectrolyte) solution to raw water to coagulate suspended matter into groups large enough to be removed by the multimedia filter.

(c) Sodium Hex Feed Pump: Feeds diluted sodium hex solution (sodium hexametaphosphate) to prevent calcium scaling in the pipes of the ROWPU.

(d) Citric Acid Feed Pump: Feeds diluted acid (tricarboxylic acid) to the raw water, to lower the pH and strengthen the membranes elements for better rejection.

(12) Circuit Breakers: Circuit breakers are located in the junction box. They are used to shut off power to pump motors, utility outlets, and backwash timer if there is an electrical malfunction in the circuit.

(13) Junction Box: Junction box is located on the right side of the control panel. It is used for attaching pump cords and has two utility outlets.

(14) Control Panel: The control panel consists of various gauges, valves, lights, switches, and hose connections.

(a) Control Box Assembly: Located on the control panel, it consists of indicator lamps and switches to start, operate, and stop all pumps.

1 R.O. Pump Low Pressure Indicator Lamp: Lamp that comes on when R.O. pump suction pressure drops below 10 psi. This lamp also indicates that the R.O. pump should have shut off.

2 R.O. Pump High Pressure Indicator Lamp: Lamp that comes on when R.O. pump discharge pressure is higher than 1250 psi. This lamp also indicates that the R.O. pump should have shut off.

(b) Emergency Stop Switch: When pushed in, this switch shuts off power to all pump motors.

WARNING, THE EMERGENCY STOP SWITCH SHOULD NOT BE USED TO SHUT OFF THE ROWPU EXCEPT IN EMERGENCY CONDITIONS. TO DO SO CAN CAUSE DAMAGE TO THE EQUIPMENT. PUSH IN EMERGENCY STOP BUTTON ONLY IF ANY OF THE FOLLOWING CONDITIONS EXIST:

1 Operators could be injured or the equipment could be damaged if operation of the ROWPU is allowed to continue.

2 Red high pressure lamp associated with R.O. pump comes on but the unit does not automatically stop.

3 Yellow low pressure lamp associated with R.O. pump comes on but the unit does not automatically stop.

4 Some other serious trouble (malfunction) is indicated by noise, vibration, large water leaks, etc.

5 When backwash pump lamp and backwash pump itself comes on during normal filtering operation.

6 When high pressure relief valve activates during normal operation.

7 When rupture disc ruptures during normal operation.

(15) Safety Valves: The ROWPU has two automatic safety valves. The high pressure relief valve and the rupture disc assembly.

(a) The high pressure relief valve is located after the pulse dampener, if R.O. pressure goes above 1100 psi, this valve opens automatically and discharges water through a pipe located between the booster pump and chemical feed pumps.

NOTE: If this valve activates, immediately open the regulate product flow valve and push in the emergency stop switch. When the pressure drops below 1100 psi the valve will automatically close.

(b) The rupture disc assembly is located on the discharge end of the R.O pump. The rupture disc is a thin sheet of

metal that tears when the R.O. pump discharge pressure exceeds 1425 psi and high pressure switch failed to activate.

NOTE: If the rupture disc assembly ever activates, open the regulate product flow valve and push in the emergency stop switch. When pressure drops, replace the ruptured disc and notify maintenance to troubleshoot the high pressure relief valve and the high pressure switch.

(16) Color Coded Pipes: The ROWPU piping is identified by color according to their functions. The function and color are as follows:

(a) Raw water - Black band

(b) Backwash waste - Red band

(c) Filtered water - Yellow band

(d) Product water - Blue band

(e) Brine discharge - Purple band

(17) Storage Boxes:

(a) Chemical Chest: Stores a five day supply of chemicals needed to purify water. It also contains several SL-3 components.

(b) Tool Chest: Houses all the toolkits necessary to maintain the unit. It also stores the remaining SL-3 components.

(18) NBC Canisters:

(a) Radiation: Used to absorb radioactive contamination from the product water. This canister is good for only 100 hrs. of filtration at which time it will be tagged and labeled for disposal.

(b) Chemical: Used to absorb chemical agent contamination from the product water. This canister is good for 100 hrs. of filtration at which time it will be tagged and labeled for disposal.

(19) Hoses: The unit is provided with both suction and discharge hoses.

(20) Float: Used to keep strainer from sucking from the bottom of the water source.

(21) 3000 Gal Tanks: The ROWPU is provided with three 3000 gallon tanks. These tanks will be used for the following:

(a) Raw water tank.

(b) Backwash tank.

(c) Product water tank.

4. The Fresh Water Purification System (3000 LMT):

a. The Fresh Water Purification Unit (3000 LMT) is a frame mounted, skid based, diesel operated, diatomite type unit capable of purifying a fresh water source (less than 1,500 TDS) at a rate of 3000 gallons per hour. The unit was designed to be transported by tactical vehicle or air lifted by helicopter to remote sites. The unit weighs 680 lbs.

b. The 3000 LMT consists of the following components:

(1) Main Frame: Holds three modules, (pump module, control module and filter module). Additionally the main frame also consists of the following SL-3 components:

(a) 1- tool kit

(b) 3- 10'x 2" suction hoses

(c) 3- 25'x 2" suction hoses

(d) 1- 50'x 2" pump discharge hose

(e) 1- 50'x 2" waste hose

(f) 1- 50'x 1-1/2" fresh water hose

(g) 1- 50'x 1-1/2" fire hose with nozzle

(h) 1- 5- gal. polymer can assembly

(i) 1- 2000 ml D.E. measuring container

(j) 1- chlorine measuring container

(k) 1- chlorine test kit

(l) 1- suction strainer

(m) 1- buoy

(n) 1- collapsible priming bucket

(o) 1- lifting sling (for helicopter lift)

(2) Pump Module: Is suitable for a wide variety of fresh and

saltwater applications. It is very corrosion resistant, made of bronze and stainless steel. The pump is a centrifugal, self-priming, lightweight, air cooled, single cylinder, 4 cycle overhead valve engine with direct fuel injection. It also:

(a) is rated at 160 gpm

(b) has 1 gal. capacity diesel fuel tank (0.4 GPH CONSUMPTION)

NOTE:
0.4 GPH x 20 hrs = 8 gals/day

(c) has 1 quart capacity (15-W-40) oil crankcase.

(3) Control Module: Houses the diatomaceous earth tank, hypochlorinator tank, gauges, operating valves, ratio feeder adjusting knobs, and various piping systems.

(a) Diatomaceous Earth (D.E.) Slurry Tank: Stores the Diatomaceous earth slurry mixture. The diatomaceous earth is what actually filters the water. When the D.E. adheres itself to the filter, it is then called pre coat or filter cake.

NOTE: D.E. is any class of minute planktonic unicellular or colonial algae with silidified skeletons that form diatomite which is a light friable siliceous material derived chiefly from diatom remains and used especially as a filter.

(b) Chlorine Tank: Stores the chlorine slurry mixture. Chlorine is a disinfectant that kills bacteria in the water which in turn helps keep the water safe for consumption.

(c) Gauges: Monitor the operation of the 3000 LMT and indicates to the operator when the unit needs backwashing.

(d) Operating Valves: Routes the flow of water during various stages of operation.

(e) Chemical Feeders: Used to adjust the amount of chemicals introduced into the unit. The feeders measure on a scale of 0-10 with the optimum setting of 5.

(4) Filter Module: Contains the filter segments on which the D.E. is layered. The grade of the D.E. and the consistency of the filter cake is what determines the filtering efficiency of the unit. The module also houses a compartment for D.E. storage.

5. Support Requirements:

a. ROWPU:

Requirements	Qty	Purpose
Generator	1 ea.	Provides electrical power
LVS/5-Ton	1 ea.	Provides transportation
Tram/forklift	1 ea.	Provides unloading and loading
Chlorine	42 lbs.	Provided in SL-3 is enough chemicals to start operation
Sodium Hex	21 lbs.	
Citric acid	45 lbs.	
Polymer	6 gal.	
85-140 wt. Gear oil	1 pt.	Provided for Chemical Feed Pump (Changed every 100 hrs)
30-40 wt. HD non-detergent oil	2 gal.	Provided for R.O. pump (Changed every 700 hrs)

b. 3000 LMT:

Requirements	Qty	Purpose
5-Ton/HMMWV	1 ea.	Provides transportation
Tram/forklift	1 ea.	Provides unloading and loading
Chlorine	5 lbs.	Provided in SL-3 is enough chemicals to start operation
Diatomaceous earth	72 lbs.	
Polymer	2 gal.	
30 wt. Oil	1 qt.	Provided for Raw Water Pump (Changed every 100 hrs)
Diesel Fuel		Provided for Raw Water Pump

6. Safety Precautions:

a. Properly ground the generator and purification unit.

b. Provide fire extinguishers and establish fire points.

c. Ensure operators are wearing hearing protection.

d. Have NO SMOKING, NOISE HAZARD, AND CHEMICALS signs posted.

e. Do not store or expose chemicals in direct sunlight or outdoors.

f. Provide aprons, gloves, goggles, dust mask, or respirators when handling chemicals.

g. Ensure all product water tanks are covered.

h. Set up eye wash stations.

i. Check local EPA regulations in regards to disposing of waste (brine) water.

7. Task Requirement:

a. Task requirements will be derived from the information covered in this lesson. You will be required to determine the minimum amount of personnel, by MOS and rank, that it will take to set up and operate each ROWPU/3000 LMT used in your plan. The number of personnel will vary for each group depending on the amount of equipment used and the task assignment.

b. The ROWPU requires 2 Marines to setup and operate.

c. The 3000 LMT requires 2 Marines to operate and 6 to setup.

8. Developing a Water Point:

a. A water source developed for military use is called a water point. The purpose for the development of a water point is to increase the quality and quantity of water, as well as making it more readily available for treatment and distribution.

b. The following objectives should be directed toward the development of a water point:

(1) Increase the quantity of potable water available.

(2) Improve the quality of water produced.

(3) Lessen distribution problems.

(4) Decrease maintenance requirements.

(5) Improve security.

(6) Improve living condition of water point personnel.

c. Proper planning is essential to the orderly development of a water point and should be foremost in the minds of reconnaissance and supervisory personnel. When possible, planners should select the site requiring the least improvement. They also should give priority to removing obstacles that limit operations.

d. There are a two development considerations which apply to the development of a water point. They are discussed below:

(1) Order:

(a) The problems encountered at each site and tactical situation determine the order for improvements at water points. As planners, you should give priority to those conditions which are necessary to establish the water point.

(b) For example, in jungle terrain where water is readily available and cover and concealment are good, but routes of communications are poor and the enemy is present, consider distribution facilities and security first.

(2) Extent: The extent to which a water point is developed depends mainly on time, labor, personnel, and materials available. At forward deployed sites, develop enough water to supply potable water to using units. However, in the rear area, the extent of development will vary with the size of the water point, the problems to overcome, and the permanency of the installation.

9. Site Improvement Considerations:

a. Drainage:

(1) The importance for providing good drainage can't be overemphasized. Wastewater from treatment units, leakage from storage tanks, and spillage from distribution units may cause the area to become so wet and muddy, that it will render the water point inoperable.

(2) During the winter months water may freeze, causing a serious safety hazard for personnel and equipment. Avoid such conditions by having good drainage at each site. Always direct drainage downstream from the purification, storage, and distribution operations.

b. Storage Facilities: Should be large enough to meet daily water peak demand. This will eliminate long waits at the water point by consumers and ensure sufficient quantities of water is available for mission requirements.

c. Road Networks:

(1) A satisfactory water point must be accessible to vehicles and personnel. If vehicles cannot get to the point of distribution, the water point no longer serves it's purpose.

(2) The load capacity of roads should be sufficient to withstand the heaviest vehicles under all weather conditions. Locate the water point on improved roads whenever possible but avoid main supply routes. A good road net should include the following provisions:

1 Turnouts and Turnarounds - a turnout may be the widened section of the main road or a new one-way road past the water point. The type used depends on labor and the equipment available.

2 Traffic Signs - the route to the water point should be well marked, visibly clear, with posted signs at all critical points within two miles of the water point.

3 Checkpoints - set up checkpoints at the entrance and exits of the water point. Give personnel entering the area a safety brief. Use the checkpoints not only to control traffic but also to monitor the issue of water.

d. Camouflage:

(1) Camouflage misleads the enemy by misrepresenting the true identity of an installation, an activity, or an item of equipment. The water point may not be within the boundaries of a base cluster which, as a result, imposes a special problem of security.

(2) The best means of reducing the chances of attack is to deny the enemy the information concerning the location of the water points. This can be done by the maximum use of camouflage netting.

e. Bivouac: Conveniently locate water supply personnel with respect to the water point. Select a bivouac area for water supply personnel and security forces. In selecting a site, consider security, sanitation, and comfort of the troops. This will facilitate the arrangement of shifts and make personnel readily available in case of emergencies.

f. Security:

(1) Troop morale, welfare, and health depend on a reliable source of potable water. Therefore, commanders must take measures to provide security for water points. A lack of security could result in complete loss of a water point; or the enemy could contaminate storage and distribution facilities, thus disabling or killing those who drink the water.

(2) Communication channels to the water points should be kept open. Keep personnel informed of the tactical situation. Provide shelters to protect personnel from the effects of NBC if at all possible.

REFERENCES

FM 10-52, Field water supply.

TM-08580A-10/1, Reverse Osmosis Purification Unit.

TM-08580A-24/2, Reverse Osmosis Purification Unit.

TM-08580A-24/3, Reverse Osmosis Purification Unit.

TM-08580B-10/1, Reverse Osmosis Purification Unit.

TM-08580C-10/1, Reverse Osmosis Purification Unit.

TM-08580C-24/2, Reverse Osmosis Purification Unit.

TM-08580C-24P/3, Reverse Osmosis Purification Unit.

TM-09777A-14/1, 3000 LMT.

1. **Set up procedures of the ROWPU**:

a. Site selection:

(1) Stage the ROWPU within 75 ft. from your water source on firm, level ground.

(2) If a stream or lake is used as the raw water source, stage the ROWPU upstream from the camp.

(3) Adequate cover and concealment.

(4) Sufficient road nets.

(5) Good drainage.

(6) Test water.

(a) Take TDS reading.

(b) Take Chlorine Residual.

b. Installation:

(1) Roll up canvas cover over the ROWPU frame and fasten with tie-back straps.

(2) Remove the two frame cross braces. Release cargo straps.

(3) Remove float and five chemical pails.

(4) If carrying storage tanks with the ROWPU remove them.

(5) Remove nine 1-1/2" suction hoses one 2" suction hose, six 1-1/2 discharge hoses, and three 2" discharge hoses.

(6) Remove the two storage boxes but do not empty them.

(7) Remove chemical container assembly and locate it in front of the chemical feed pump.

(8) Remove distribution pump.

(9) Install raw water system:

(a) Remove both raw water pumps.

(b) Connect electrical cables to the junction box.

(c) Install a strainer and float at the end of the raw water suction hose connected to pump suction, and drop the discharge hose into the raw water tank.

(d) Connect suction hose and then connect the discharge hose between the pump discharge outlet and raw water inlet connection on the ROWPU.

(10) Install backwash water system:

(a) Remove the backwash pump.

(b) Connect electrical cable from pump to junction box.

(c) Install the backwash strainer onto the discharge side of the backwash pump by bolting the strainer bracket to the frame

(d) Connect a 2" gate valve to the bottom of backwash tank. Attach a 2" suction hose from gate valve to the backwash pump. Ensure gate valve is closed.

(e) Connect 2" discharge hose from the backwash pump strainer to on the backwash water inlet connection on ROWPU.

(f) Connect 1-1/2" discharge hose from brine outlet on the ROWPU and drop it into the backwash tank.

(11) Connect product water system:

(a) Connect a 1-1/2" suction hose to the product water outlet on the ROWPU. Connect a 1-1/2" discharge hose to the suction hose. Product water hose will lay next to product water tank until the water has been tested.

(b) If using two storage tanks, connect a 1-1/2" suction hose between each tank.

(c) Hook up distribution pump to storage tank.

(d) Connect electrical cable from the distribution pump to the junction box.

(12) Connect waste water system:

(a) Connect 2" discharge hose from vent vessel outlet on ROWPU to the drainage area.

(b) Connect 2" discharge hose from waste water outlet on ROWPU to the drainage area.

(13) Recheck all hose connections to ensure they are tight.

(14) Install chemical feed system:

(a) Hoses are stored attached to pump.

(b) Install quick-disconnect end of hoses to each 5

gallon container.

(c) Ensure both suction and return hoses are sealed tight and to the proper container.

(d) Set chemical feed pump valves to "Prime".

(15) Ground the ROWPU with the grounding rod.

(16) Hook up the power cable to the ROWPU.

(a) If the motors to the pumps run in reverse, change two of the hot leads from one stud to another: L1 - L2 or L3.

(b) If wire is not marked with industrial tags, a continuity check will be necessary to correctly connect the unit.

(17) Ensure power is off until the unit is completely set up for operation.

c. Preposition valves and switches:

(1) Turn off all breakers.

(2) Open vent valves:

(a) Vent cartridge filter valve.

(b) Vent pulse dampener valve.

(c) Vent multimedia filter valve.

(3) Set backwash valve to normal.

(4) Push in emergency stop button.

(5) Set all control box switches to STOP or OFF.

(6) Open regulate product flow valve.

(7) Open vent vessels valve.

(8) Set element cleaning switch to off.

(9) Set backwash timer knob to "Service" position.

(10) Mix the following chemical solutions in separate 3 gallon pails using best available water; brine or raw water. Ensure that water being used contains no chlorine.

(a) Calcium Hypochlorite - .2 lbs

(b) Polyelectrolyte - 53 ml

(c) Sodium Hexametaphosphate - .1 lbs

(d) Citric Acid - .75 lbs

(e) Stir solutions for at least 1 min. using wooden paddles and pour into 5 gal containers marked with their respective chemical label.

NOTE: **Do use chemical pails and wooden paddles for jobs other than those intended.**

(11) Turn chemical valves to prime position.

(12) Open product water vent valve.

(13) Close product water drain cock. Found only on the "Alpha" model.

(14) Close seven drains in the rear of the unit.

(15) Close eight product water sample valves. Found only on the "Bravo" and "Charlie" models.

d. Perform before operation checks and services:

(1) Check oil levels:

(a) R.O. pump: Oil level should be at least half to 3/4 way up on sight glass. R.O. pump holds 2 gals of OE/HDO-40 or OE/HDO-30 non-detergent oil, which is changed by the following intervals:

1 Changed before first operation

2 After the first six weeks of operation

3 Every 3 months or 1,000 hrs. of operation

(b) Chemical feed pump: Oil level should be to the middle of the sight glass on the “Alpha” model. The “Bravo” and “Charlie” models have a dip stick. Chemical feed pump holds 1 pt. of 85w-140 gear oil (with rust inhibitor).

1 Oil is checked weekly.

2 Oil is changed every 4,000 hours of operation or each year.

(2) Perform visual inspection:

(a) General: Inspect the general appearance and possible damage of the unit and all its accessories.

(b) Filters: Check for loose connections and leaking gaskets.

(c) Gauges and Indicators: Inspect for broken glass and loose mountings. Check for salt residue inside the gauges.

(d) Pumps: Check for possible damage, damaged fittings, inspect drive belts on R.O. pump.

2. **Start up procedures:**

a. Start generator and apply power load to ROWPU.

b. Turn on circuit breakers.

c. Pull out emergency stop button.

d. Jog R.O. pump to ensure motor is running in proper direction.

NOTE: R.O. pump low pressure lamp, on ROWPU control box assembly, comes on as soon as generator supplies power to the ROWPU.

e. Prime raw water pump:

(1) Make sure the drain valves are closed.

(2) Prime the pump through the suction hose.

f. Start raw water pump:

(1) Ensure the motor is running clockwise.

(2) Set switch upward to START.

(3) Hold switch up until green lamp comes on, ensure that pump starts.

(4) Release the switch.

(5) Switch will return to RUN.

(6) Look at raw water input hose, if pump is drawing water, the hose will pulsate and fill with water.

(7) The raw water flow rate will jump from 0 to 40 gpm and then gradually drop down to between 27 and 33 gpm flow.

g. Turn on chemical feed pump.

h. Prime polymer chemical feed pump:

(1) Set polymer chemical feed control knob to 5.

NOTE: Adjust controls of chemical feed pumps only while motor is running.

(2) Allow pump to run on prime until no more air bubbles are seen in the return line.

NOTE: If pump fails to prime, set control knob to 8.5. Pump will pick up the prime in a few seconds. Return control knob to 5.

i. Calibrate the polymer:

(1) Set control knob to 1.5 (On "Alpha" models, set to 2.6)

(2) Obtain your 100 ml graduated plastic cylinder.

(3) While the polymer pump is running, disconnect the polymer return line, use the 100 ml cylinder and time the flow for 1 minute.

(4) Flow should be 60 ml. If not, adjust the control knob setting until you get a 60 ml per minute flow.

(5) Record the knob setting.

NOTE: A clarity test will be performed once all chemicals have been primed and calibrated.

j. With raw water pump working and the chemical feed pump running, set the polymer pump valve from PRIME to RUN.

k. Go around to the control panel.

l. Close vent multimedia filter valve as soon as a full stream of water flows out of vent pipe (located at the bottom right-hand front of the unit, below R.O. pump belt guard).

m. Start booster pump.

n. Close vent cartridge filter valve as soon as a full stream of water flows out of vent pipe.

o. Reset R.O. pump:

(1) Set R.O. pump reset switch upward to RESET.

(2) Release switch.

(3) Yellow R.O. pump low pressure lamp goes off.

(4) Switch returns to ON.

p. Start R.O. pump.

NOTE: R.O. pump will not start unless it is reset.

q. Observe R.O. pump:

(1) Make sure the R.O. pump is running smoothly.

(2) Make sure the belts are not slapping.

r. Close vent pulse dampener valve as soon as you see a full stream of water coming from the vent pipe.

s. At this time, due to the lack of pressure, the semi-filtered water is backed up at the R.O. vessels and exiting the ROWPU through the vent vessel line.

t. Observe vent vessel hose for clarity. Within approximately 10 minutes the water should be clear.

u. While waiting, prime and calibrate the chlorine and sodium hex chemical pumps just like the polymer chemical pump.

v. Set citric acid pump knob to 8.5, which is the max setting, and leave it on prime.

w. After calibrating sodium hex and chlorine pumps, set sodium hex valve to RUN and leave chlorine on PRIME.

x. Perform a turbidity test of the water once the vent vessel water has cleared up:

(1) Obtain the 1000 ml graduate cylinder with the white bulls-eye set in a black background on the bottom of the tube.

(2) Draw a sample of 600 ml of water from drain NO. 1 cartridge filter into the turbidity tube.

(3) Look down into the turbidity tube and you should be able to see both the white bulls-eye and the black disc at the bottom of the tube clearly.

(4) If both cannot be seen clearly (water is chalky), run the ROWPU another 10 minutes. Repeat the sampling test.

(5) If after second sampling test, water is not clear, readjust polymer chemical feed control knob setting down in .5 measurements.

(6) Wait 5 minutes then examine another sample of water.

(7) If water is still not clear, repeat this process and keep reducing the chemical setting by .5 each time and waiting 5 minutes until the water is clear.

NOTE: **Obtaining a clear sample of water means that you have the right amount of polymer mixed with raw water for better filtration.**

y. **Slowly** close vent vessels valve. This closes off the water's path of least resistance and allows filtered water to enter R.O. vessels.

z. **Slowly** adjust regulate product flow valve clock-wise:

(1) Watch for rise on product water flow gauge.

(2) Watch for decrease on brine flow gauge.

(3) Watch for rising pressure on R.O. pressure PSI gauge.

(4) Stop turning the valve when the 1st extreme has been met.

NOTE: Normally, product water flow should not exceed 16 gpm. R.O. pressure psi gauge should not be above 960 psi.

NOTE: **Close regulate product flow valve very slowly. Sudden high pressure to the R.O. vessels could damage the R.O. elements.**

aa. Set chlorine valve to RUN position.

bb. Close vent product water valve.

3. **Perform during operation checks and services:**

a. Listen for unusual noises and look for any leaks.

b. Monitor all gauges.

c. Record gauge readings each hour and log it in operators log.

GAUGE/INDICATOR	NORMAL READINGS	TROUBLE POINT READING
Raw Water Flow	27-33 GPM	Below 25 GPM
Multimedia Filter	0-10 PSID	Over 10 PSID
Cartridge Filter	1-20 PSID	Over 20 PSID
Brine Flow	16-24 GPM	Below 15 GPM
R.O. Pressure PSI		
Fresh Water	500 PSI	Above 500 PSID
Brackish Water	500 PSI	Above 500 PSID
Salt Water	960 PSI	Above 960 PSID
Product Water Flow		
Fresh Water	Up to 16 GPM	Above 16 GPM
Brackish Water	Up to 16 GPM	Above 16 GPM
Salt Water	6-12 GPM	Above 12 GPM
R.O. Vessels	50-100 PSID	Over 100 PSID
Product Water TDS	Below 1500 TDS	Above 1500 TDS
Product Water Chlorine	1.0-2.0 ppm (5.0 for storage)	Below 1.0 ppm (below 5.0 for storage)
Brine Water pH	Below **8.0**	Above 8.0 Ph

d. Obtain chlorine residual reading of product water from product water hose. If too high or low, adjust setting on chlorine chemical feed pump.

e. Take a TDS reading of product water.

f. Take a pH of brine water from brine hose. If pH is above 8.0, a citric acid feed is necessary to lower pH between 5.0 - 8.0.

NOTE: The R.O. membranes operate best in water containing a pH of 5.5. For example: water with a pH of 5.5 might produce 500 ppm TDS product water, whereas the same water with a pH of 7.5 might produce a product water with 1000-1500 ppm TDS. Due to the cost of citric acid, it is recommended to use citric acid only after each 20 hours of operation.

(1) Perform Citric Acid Feed:

(a) Set citric acid feed pump valve on RUN.

(b) Wait until 5 gal container is empty.

(c) Draw a sample from the brine hose and check pH reading.

(d) If reading is above 8, feed a new batch of citric acid with 1-1/2 pounds of citric acid with 3 gallons of brine water.

(e) When reading drops below 8.0,the following must be done:

1 Set citric acid chemical feed pump valve back to PRIME.

2 Place product water hose in product water tank.

4. **Daily water production log (DA Form 1713-R):**

a. General: Logs are important because the information from these forms are used to schedule resupply of chemicals, POL, and maintenance of the equipment. The following is a guidance on completing the DA Form 1713-R.

b. Hourly chemical dosage log:

(1) Shift Number: - Enter the shift hours on this block.

(2) Water Point Number/ROWPU Number: Enter the assigned water point number and ROWPU serial number.

(3) NCO in Charge: - Enter the name of the NCO supervising the water point.

(4) Date: Write out the date at the start of each new day.

(5) Time: Enter the time the ROWPU was started and stopped. Also log the time the ROWPU is shut down for maintenance.

(6) Citric Acid, Sodium Hex, Chlorine, and Polymer: Enter the initial knob setting and amount of chemicals used for the initial charge. Make a separate log entry every time you recharge.

(7) pH: Enter the initial pH reading of the raw water and the pH from the product water.

(8) Chlorine residual: Enter the residual reading taken from the product water after at least 30 minutes contact time.

(9) Remarks: Enter the reason that the production was halted (for example, backwashing, R.O. element cleaning, cartridge filter replacement). Also note any significant event that may affect water point operations.

(10) Chemicals Used: Enter the total amount of each chemical used for the shift. Start a new form for each shift.

(11) Chemicals on Hand: Enter the total amount of chemicals you have on hand for this ROWPU at the end of the shift.

c. Gauge and indicator log:

(1) Time: Enter the time you started the ROWPU and the time it was shut down.

(2) Product Water Flow: Enter the reading from the product water flow gauge on the ROWPU.

(3) Reverse Osmosis Pressure: Enter the reading from the R.O. pressure PSI gauge.

(4) Cartridge Filter: Enter the pressure differential reading from the cartridge filter gauge.

(5) Multimedia Filter: Enter the pressure differential reading from the multimedia filter gauge.

(6) Raw Water Flow: Enter the reading from the raw water flow gauge.

(7) Brine Flow: Enter the reading from the brine flow gauge.

(8) Reverse Osmosis Vessels: Enter the pressure differential reading from the R.O. vessels gauge.

(9) Total Dissolved Solids: Enter the TDS reading.

(10) Remarks: Enter the reason that the production was halted (for example, backwashing, R.O. element cleaning, cartridge filter replacement). Also note ant significant event that may affect water point operations.

(11) Total Hours Operated: Enter the total amount of hours the unit was operated during the shift.

(12) POL Used: Enter the total amount of each POL used for the shift. Start a new form for each shift.

(13) POL on Hand: Enter the total amount of POL you have on hand for this ROWPU at the end of the shift.

5. **Shutdown procedures**:

a. Normal shutdown:

(1) Remove product water hose from product water tank and set the hose in the drainage area.

(2) Set all chemical pump valves to prime and wait 2 minutes for chlorine to exit the product water outlet.

(3) Open regulate product flow valve slowly.

(4) Wait 5 minutes before opening the vent vessels valve.

(5) Open four vent valves:

(a) Vent cartridge filter valve.

(b) Vent pulse damper valve.

(c) Vent multimedia filter valve.

(d) Vent product water valve.

(6) Place Reverse Osmosis pump switch down to STOP (yellow low pressure lamp will come on).

(7) Place booster pump switch down to STOP.

(8) Place chemical feed pump switch down to STOP.

(9) Place raw water pump switch down to STOP.

(10) Push in emergency stop button.

(11) Turn off circuit breakers.

(12) Turn off generator.

NOTE: If unit will not be operated within 12 hours, open the seven drains and drain the unit.

b. Long shutdown:

NOTE: Long shutdowns will be completed at the end of operations.

(1) Shut down ROWPU normally.

(2) Backwash the multimedia filter

(3) Perform R.O. element cleaning.

(4) Remove the strainer and hose from water source.

(5) Drain ROWPU pipes, filters and connections:

(a) Open seven drain valves.

(b) Open four vent valves.

(6) Drain R.O. pump.

(7) Drain booster pump.

(8) Drain chemical feed pumps.

(9) Drain raw water pumps #1 and #2.

(10) Drain distribution pump.

(11) Shut off all electrical power.

(12) Disconnect all hoses and pumps from ROWPU.

(13) Roll up all hoses and power cables.

(14) Repack all components of ROWPU.

6. **Perform after operation checks and services:**

a. General: Inspect general appearance of the unit. Inspect for water leaks, loose or missing bolts, screws, nuts, and hoses. Inspect for signs of damage and loose or broken cable connections.

b. Frame and Equipment: Remove oil, grease, mud, chemical spills, and other matter from all parts of Reverse Osmosis Water Purification Unit.

c. Multimedia and Cartridge Filters: Inspect for leaks and loose connections and mountings.

d. Gauges and Flow Indicators: Inspect for broken glass and look for loose mountings and tube connections.

e. Chemical Feed Pump: Inspect for loose mounting nuts. Inspect for cracked or broken fittings. Check oil level and condition of oil.

f. Reverse Osmosis Pump: Check all five V-belts for cracks, rubbing and signs of wear. Check belt tension. Check oil level and condition.

7. **Installation of nuclear, biological, and chemical cartridges:**

a. The ROWPU has overpack items which are used as a post-treatment when nuclear or chemical contaminants are present. The equipment consists of a cartridge to remove nuclear contaminants, a cartridge used to remove chemical contaminants, and the adapters, bushings, clamps, couplings, reducers, and tubing needed for assembly.

WARNING: RADIOACTIVE CONTAMINANTS ARE POTENTIALLY HAZARDOUS. USE EXTREME CARE IN REPLACING CARTRIDGES AND FOLLOW SAFETY PROCEDURES IN THEIR HANDLING AND DISPOSAL.

NOTE: Do not operate chlorination feed pump during NBC cartridges operation.

b. For nuclear, biological or chemical contamination, use both the cartridge marked "FOR USE WITH RADIOACTIVE CONTAMINATED WATER ONLY" and the cartridge marked "FOR USE WITH CHEMICALLY CONTAMINATED WATER ONLY."

c. Exchange the inlet and outlet raw water pump adapter which is used in the NBC system and prepare to assemble NBC filters between two raw water tanks.

d. Use one of the raw water pumps to force the water through the NBC cartridges.

e. Install raw water pump:

(1) Install 1-1/2 inch suction hose from raw water tank and swivel adapter on raw water pump.

(2) Attach female end of distribution (suction or discharge) hose to straight adapter on raw water pump.

(3) Attach swivel adapter to gate valve and attach male end of distribution hose to swivel adapter.

(4) Attach shoulder bushing and adapter to gate valve.

NOTE: The NBC cartridges should be positioned so that the cartridge marked "FOR USE WITH CHEMICALLY CONTAMINATED WATER ONLY" is first in the series. Position the cartridge marked "FOR USE WITH RADIOACTIVE CONTAMINATED WATER" so that water is filtered through this cartridge

f. Assemble the NBC cartridge in series.

NOTE: Pay special attention to the input and output labels on top of the NBC cartridges when connecting the ¾ inch reinforced flexible tubing to the cartridges.

(1) Slide clamp over end of one section of 3/4 inch x 80 inch flexible tubing. Attach tubing to adapter on gate valve and close clamp.

(2) Slide clamp over other end of tubing.

(3) Remove plug from INLET port on FOR USE WITH CHEMICALLY CONTAMINATED WATER cartridge and insert adapter.

(4) Attach tubing to adapter on INLET port and close clamp.

(5) Cut one section of 3/4 inch x 80 inch flexible tubing to a maximum length of 24 inches.

(6) Slide clamp over end of tubing.

(7) Remove plug from OUTLET port on FOR USE WITH CHEMICALLY CONTAMINATED WATER cartridge and insert adapter into cartridge.

(8) Attach tubing to adapter on OUTLET port and close clamp.

(9) Remove plug from INLET port on FOR USE WITH RADIOACTIVE CONTAMINATED WATER cartridge and insert adapter in cartridge.

(10) Slide clamp over end of tubing.

(11) Attach tubing to adapter on INLET port and close clamp.

(12) Slide clamp over end of second section of 3/4 inch x 80 inch flexible tubing.

(13) Remove plug from OUTLET port on FOR USE WITH RADIOACTIVE CONTAMINATED WATER cartridge and insert adapter.

(14) Attach tubing to adapter on OUTLET port and close clamp.

g. Complete connection of NBC cartridge to second raw water tank.

(1) Slide clamp over remaining end of 3/4 inch x 80 inch flexible tubing.

(2) Insert adapter into tubing and close clamp.

(3) Attach shoulder bushing, pipe coupling, and straight adapter to 1-1/2 inch discharge hose and connect to second raw water tank.

NOTE: Do not operate chlorination feed pump during NBC operation.

h. During NBC operation, it is necessary to chlorinate the second tank by hand.

i. With the exception of the chlorination feed pump, operate the ROWPU using normal operating procedures.

j. Change the cartridges after every 100 hours of operating time.

8. **Backwash of the multimedia filter:**

a. Reason for backwash: To remove any dirt and solid material caught inside multimedia filter layers. During the backwash cycle the water from the backwash tank is pumped by the backwash pump through the multimedia filter layers in reverse (from bottom to top) and any dirt and solid materials are washed out from the filter media.

b. When to backwash: The multimedia filter should be backwashed:

(1) Every 20 hours of operation.

(2) Multimedia filter gauge rises 5 psid above the initial reading.

(3) When R.O. unit will not be operated for a long time.

(4) Before movement.

c. Performing backwash:

(1) Shut down the R.O. unit normally (short shutdown).

(2) Check water level in backwash tank. Ensure you have at least 1500 gallons of water in the backwash tank.

(3) Open the 2" gate valve attached to the backwash tank.

(4) Prime backwash pump. (Open drain cock on the bottom of the pump to get a water flow.)

(5) Turn backwash valve handle down to "backwash".

(6) Set START backwash switch up and release immediately.

(7) Backwash pump and backwash cycle should start within 2 to 3 seconds. The cycle is started when the white lamp comes on, and is ended when the backwash pump stops and white lamp goes OFF. The complete backwash cycle lasts about 13 minutes.

NOTE: During backwash cycle, make sure the backwash tank does not go dry before the backwash cycle is completed. The proper reading on the backwash gauge is 0, 70, or 120, depending on which cycle of backwash the unit is in.

(8) When backwash is completed and the white lamp goes off, turn backwash valve handle to normal.

(9) Close the gate valve on the backwash tank valve.

(10) Start the R.O. unit normally.

CAUTION: BACKWASH SHOULD NEVER BE PERFORMED IF THE R.O. UNIT MULTIMEDIA FILTER IS DRAINED OR PARTIALLY DRAINED. IF SO, OPERATE THE R.O. UNIT NORMALLY FOR AT LEAST 30 MINUTES NONSTOP TO PRIME THE FILTER AND TO REMOVE ALL AIR FROM INSIDE THE FILTER.

9. **R.O. Element cleaning:**

a. It will be necessary to clean the R.O. elements to improve total dissolved solids (TDS) rejection, and reduce operating pressure (RO pressure PSI). Two methods of cleaning elements are available. One method, which is used more often, is to flush citric acid solution through the vessels. The second method is to flush a Sodium Bisulfate cleaning solution through the R.O. vessels. These solutions remove unwanted material from the membranes.

b. Conditions requiring element cleaning:

(1) Whenever the pressure in the R.O. vessels shown on the R.O. pressure PSI indicator rises to either 960 for seawater or 500 for fresh water, and at the same time the product water flow gauge drops below minimum reading (6 GPM).

(2) Whenever product water output drops several gallons per minute on product water flow indicator with no change in raw water temperature. The unit operates better in warmer weather than in colder, ideal is 74^{o}F.

(3) Whenever brine flow increases noticeably and adjustment regulate product flow valve does not correct the product water flow indication.

(4) When R.O. vessel pressure increases by 20% over the initial reading.

c. R.O. Element Cleaning Procedure:

(1) Perform a normal shutdown.

(2) Backwash multimedia filter.

(3) After the completion of backwash, water level in backwash tank should be 7 inches. Check for a 7 inch brine water level, with telescoping aluminum mixing paddle.

(4) Adjust the pH of backwash water between 3.5 - 4.0 by adding 1 lbs. of citric acid and stir until all granules are dissolved. If needed, add more until pH is correct.

NOTE: The pH of water must not be lower than 3.5. If lower, add brine water to raise the pH.

(5) Remove the hose from the backwash inlet on the control panel and connect it to the Vent Vessels line. The vent vessel hose can be placed on the ground until normal operation is continued.

(6) Open the 2" gate valve on the bottom of the backwash tank.

(7) Push element cleaning switch up to START position.

(8) Brine flow indicator should show a flow of 16 gpm or more.

(9) Every 5 minutes, check pH of the water discharging back into the backwash tank. The water should read near but not below a pH of 3.5. If it isn't, add 1 pound of citric acid at 5 minute intervals until it is.

(9) Allow citric acid solution to flow for 45 minutes or until the temperature of the water reaches 120 degrees F. Temperature of water can be checked by using thermometer in SL-3 storage box.

(10) To stop flushing, push the element cleaning switch down to OFF.

(11) Reconnect hoses on unit for normal operation.

(12) Drain the citric acid solution into a shallow, man-made lagoon, a reasonable distance away from the unit.

(13) Perform start-up procedures for normal operation.

(14) Allow ROWPU to operate for 10 min. to rinse the R.O. vessels.

(15) Perform operational adjustments.

(16) Take a pH of the brine water. If pH is below 8.0, continue to operate unit and document all gauge readings.

NOTE: If the regulate product flow valve adjustment will not give a proper product water flow indicator reading after 2 hours of operation, shut down the ROWPU normally.

(17) Flush out the ROWPU with 800 ml of Triton X Detergent to 1500 gal. of backwash water.

10. **R.O. element replacement**:

a. Pre-removal Procedures:

(1) Shut the ROWPU down normally.

(2) Open all vents, drains, and controls.

(3) Mark the end caps and vessel alignment marks, to insure that end caps are installed in the same position to reduce chances of leaks.

b. End Cap Removal:

(1) Open quick disconnect and pull out tube.

(2) Remove nut, screw, clamp, and coupling.

(3) Loosen nut on elbow and swing elbow away from the end cap.

(4) Remove end cap nuts and washers from the end cap.

CAUTION: DO NOT ATTEMPT TO PRY END CAP FROM VESSEL. THIS COULD DAMAGE THE SEAL.

(5) Screw two end cap puller bolts (1/4 - 20 x 20 in.) into threaded holes in the end cap.

(6) Alternately rotate each bolt one complete turn until end cap and O-ring are separated from the R.O. pressure tube. Remove end cap and O-ring.

(7) Repeat this procedure to remove the rear end cap.

c. Removal of R.O. Elements:

(1) Assemble element puller:

(a) Connect together the puller rod and puller rod handle.

(b) Insert elements puller into R.O. vessel. Push puller through end connector, through the product water tubes of the two R.O. elements, and through the interconnector between the two R.O. elements.

(c) Place element puller plate on assembled element puller and secure with flat washer and nut.

(2) Slowly pull both R.O. elements from R.O. vessel, being careful to keep element puller centered in tube. Make sure you are removing with the flow of water.

CAUTION: WHEN REMOVING R.O. ELEMENTS FROM R.O. VESSEL, MAKE SURE YOU REMOVE THEM FROM THE OPPOSITE END OF INSTALLATION (ALWAYS WITH THE DIRECTION OF FLOW).

(3) Disconnect the element puller after both elements are removed.

(4) Separate R.O. elements by removing R.O. element interconnector.

NOTE: It requires at least two people when removing the elements. One to pull on the element puller assembly and one to hold the elements as they come out.

d. Installation of R.O. Elements:

(1) Lubricate O-rings with glycerin, lightly.

(2) Install O-rings and end connectors.

WARNING: R.O. ELEMENTS ARE PACKAGED IN SEALED PLASTIC BAGS WITH A PROTECTIVE CHEMICAL CALLED FORMALDEHYDE WHICH IS POISONOUS; AVOID FUMES AND KEEP AWAY FROM EYES AND MOUTH. HANDLE WITH EXTREME CARE. AFTER HANDLING, WASH HANDS THOROUGHLY WITH SOAP AND WATER.

CAUTION: AFTER REMOVING R.O. ELEMENT FROM SEALED PLASTIC BAG, KEEP ELEMENTS CLEAN. FAILURE TO DO SO WILL CAN AND WILL CAUSE EARLY ELEMENT FAILURE.

(3) Remove new R.O. element from sealed plastic bag.

(4) Lubricate brine seal with glycerin.

(5) Install brine seal in groove of R.O. element, making sure open tip of the seal faces the end of element closest to the groove.

(6) Insert by hand the first R.O. element into R.O. vessel until brine seal touches end of R.O. vessel. Make sure you insert the elements with the flow of water.

NOTE: In the "Alpha" model, flow of water differs from the other models.

CAUTION: WHEN INSERTING R.O. ELEMENTS INTO R.O. VESSEL, MAKE SURE THAT THE END OF THE ELEMENT, WITHOUT THE BRINE SEAL, GOES IN FIRST, ON THE FRONT SIDE OF THE R.O. VESSEL (WITH DIRECTION OF FLOW).

(7) Place interconnector on product water tube of first R.O. element.

(8) Remove second R.O. element from sealed plastic bag.

(9) Lubricate and install brine seal.

(10) Insert product water tube of the second R.O. element into interconnector.

(11) Slide both R.O. elements and interconnector into the R.O. vessel until they are centered in the vessel.

(12) Place end connectors on both ends of product water tubes of R.O. elements.

(13) Lubricate and install end cap O-rings and end caps.

(14) Align end caps with match mark on R.O. vessel.

(15) Press end caps into studs and install ten washers and nuts onto studs. Maximum torque for end caps is 65 in./lbs. This is equivalent to about 5.4ft/lbs.

(16) Reconnect tubes and pipes to R.O. vessel.

NOTE: During operation observe for leaks.

11. **Changing the cartridge filters**:

a. Removal of cartridge filters:

(1) Remove vent line from elbow.

NOTE: The cover is installed under tension by loosening eye nuts in a few turns at a time in an alternating pattern.

(2) Loosen six eye nuts and rotate assembly out of notches in cover, remove cover with attached part.

(3) Position cover handle down.

(4) Remove eight top seat cups and spring.

(5) Remove the o-ring.

(6) Remove locknut from bolt.

(7) Remove and discard eight filter tubes.

b. Inspection of the cartridge filter assembly:

(1) Inspect eyebolts for cracks, damaged threads, bent shafts, or deformed eyes. Replace as required.

(2) Inspect o-ring for cracks, dry rot. Replace as required.

(3) Inspect elbow on the cover for cracks.

(4) Inspect bottom seat cups for deformity or looseness.

c. Installation of new cartridge filters:

(1) Replace eight filter tubes with male plastic end being inserted first to form a tight seal.

(2) Install eyebolt, washer, and eyenut.

(3) Install bolt and locknut.

(4) Relube and install o-ring.

(5) Install eight seat cups and springs.

(6) Install cover with attached parts and tighten six eye nuts.

(7) Install vent line.

NOTE: During the initial shipment of the unit from the factory, the cartridge filter tube elements are shipped outside the filter unit.

1. **Setup procedures of the 3000 LMT:**

a. Site selection:

(1) Place the unit on firm level ground.

(2) Upstream from water source.

(3) Adequate cover and concealment.

(4) Sufficient road nets (turnout and turnarounds).

(5) Good drainage area.

b. Installation:

(1) Remove pump module and hoses from the main frame and set the pump within 25 ft. of the water source, but not more than 20 ft. above the water source.

(2) Connect suction strainer and buoy to the end of suction hose.

(3) Connect 2" suction hose to pump inlet.

(4) Connect 50'x 2" pump discharge hose from pump outlet to control module inlet.

(5) Connect 50'x 2" waste hose to the waste water discharge port located on the back of the control module, and set the other end of the hose at the drainage point

(6) Connect 50'x 1-1/2" fresh water hose to the fresh water discharge port located on the back of the control module and set end of hose near storage tanks. “Do Not” place fresh water discharge hose into storage tanks until required water tests have been performed.

c. Preposition valves and switches:

(1) Mix Polymer solution at the rate of (185 ml)or 6.3 fl oz. per 5 gallons of water. Attach the 3/4" quick adapter to the 5 gallon polymer can assembly.

NOTE: Polymer creates a chemical reaction in which two or more small molecules combine to form larger molecules making filtration more efficient.

(2) Set all control valves to the "Start Up" position (W-O-F F-C-C).

(a) Clean Water Valve # 1 - Waste

(b) Waste Outlet Valve # 2 - On

(c) Backwash Valve # 3 - Filter

(d) Pre-coat Filter Valve # 4 - Filter

(e) D.E. Slurry Valve # 5 - Closed

(f) Chlorine Reservoir Valve # 6 - Closed

(3) Set all chemical feeders to "0".

(4) Close petcocks on top and bottom of the water motor.

(5) Close drain valve on Chlorine reservoir.

NOTE: If drain valves remain open, chlorine and D.E. tanks will over flow during operation.

NOTE: Wear dust mask when handling D.E. and dry chlorine.

(6) Mix 1 lb. or 16oz. bag of dry chlorine with 3 gals. Of water and pour it into the chlorine tank avoiding the calcium deposits.

NOTE: An additional gal. of water will be added later in the operation.

(7) Close drain valve on D.E. tank.

(8) Load 5 measures each (2000Ml) of D.E. into the D.E. tank for a total of 10,000 Ml.

(9) Ensure D.E. clamp is secure and open D.E. vent.

(10) Connect the 2 quick disconnect hose fittings on the side of the control module to the Filter module.

(11) Ensure drain plug is in filter.

(12) Open the filter top vent valve.

d. Conduct Before Operation Checks and Services:

(1) Check for loose, missing, and broken bolts or nuts.

(2) The pump module:

(a) Open pump primer port to prime the pump with water.

The pump can also be primed by removing suction strainer and pouring water, with a bucket through the suction hose.

(b) Check fuel level in tank: Fill with diesel if necessary.

(c) Check oil level: It must be between the min. and max. marks on the dipstick. Ensure it has the correct grade and viscosity for the operating temperature.

(d) Check the air cleaner cyclone: It should be free of sediment.

2. **Startup procedures**:

a. Put the automatic decompression device in the starting position by turning it clockwise until you hear an audible click then add ¼ turn. When properly set the knob will be at the 12 o'clock position.

b. Pull out extra fuel button if needed.

c. Set the speed regulating lever to full throttle position.

d. Insert the crank handle into the crank handle guide.

e. Crank the engine rapidly in a counterclockwise manner approximately eight times before compression is encountered and engine starts.

f. Remove crank handle from guide and properly clamp it to pump frame.

g. Run engine at full speed for 1 minute or until suction has occurred.

h. After suction has occurred, bring engine to half speed.

i. Close the filter vent valve once a steady stream of water flows from the vent hose.

j. Move valve # 4 to pre coat position and note the time.

k. Close the D.E. slurry vent valve once a steady stream of water flows from the vent.

l. Open the injector valves on each feeder head to ensure full pulsed water flow. The chlorine, D.E., and polymer bleeders are gray plastic components located behind the control module panel.

m. Open chlorine reservoir valve #6, until it fills up the tank to approximately 2" from the top, then close.

n. After approximately 8 minutes the filter should be observed through sight-glass for a good D.E. cake on the elements. Adjust all three feeder heads to a setting of 5.

p. Set valve # 4 to "filter" position.

q. Set clean water valve # 1 to "clean water" position.

3. **Conduct during operation checks and services:**

a. Take chlorine samples from product hose and make adjustments as necessary to the chlorine feeder control knob.

b. Take NTU (Nephelometric Turbidity Unit) reading:

(1) Press on/off keypad to turn on meter.

(2) Fill beaker to a depth of at least 3 in. with product water.

(3) Completely immerse probe tip and cone assembly.

(4) Press RANGE keypad until best range is selected.

(5) NTU reading will be given on digital display.

c. If chlorine residual is 1.0 - 2.0, and NTU is 1.0 or less, the clean water hose can be placed in the storage tanks.

d. At 30 minute intervals, monitor the following:

(1) Chlorine level (1.0 - 2.0)

(2) NTU (1.0 or less)

(3) D.E. tank for slurry mixture: Remove the D.E. tank lid when liquid level reaches the low level mark. Add one 2000 ml measure of D.E. and fill with water. Do not run with the mixer blade exposed to air as the slurry mixture will be inhibited.

(4) Polymer feed tank level.

(5) Chlorine residual in treated water tank.

(6) Diesel fuel remaining.

(7) Yield of raw water source. For example: a pond, tank or reservoir.

(8) Monitor the following gauge readings:

(a) Raw water pump suction gauge 15 vacuum to 15 psi.

(b) Raw water flow gauge 15-35 gpm (on control module).

(c) Raw water inlet gauge 0-35 psi (on control module).

(d) Filter differential gauges.

1 filter inlet gauge 0-40 psi.

2 filter outlet gauge 0-18 psi.

e. Backwashing:

(1) The operator should backwash the system in the event of the following:

(a) Filter differential pressure exceeds 18 psi.

(b) NTU reading is above 1.0 for two consecutive readings.

(c) Unit will be shut down for more than 8 hours.

(2) Before backwashing the system must be purged of D.E:

(a) Clean D.E. slurry tank:

1 Perform shutdown procedures on pump by holding throttle down to idle and engine comes to a complete stop.

2 Open the drain valve on bottom of the slurry tank (for approximately 5 minutes to fully drain).

3 Set D.E. feeder to "10".

4 Open D.E. injector.

5 Position valves in start up position(WOFFCC)

6 Perform startup procedures on pump.

7 After suction occurs set pump at half throttle.

8 Operate pump until water jet is clear from D.E. injector.

9 Close drain valve, D.E. injector and set all feeder heads to "0".

NOTE: If D.E. tank overflows close D.E. drain.

NOTE: Backwash A and B will be done to perform a backwash.

(b) Set the control valves to the "Backwash-A" settings:

1 Clean water valve # 1 - Waste

2 Waste outlet valve # 2 - Off

3 D.E. Slurry valve # 5 - Open

4 Backwash valve # 3 - Backwash

(c) After one minute set the control valves to the "Backwash-B" settings. Valve #3 will alternate from “Filter” to “Backwash” every 15 seconds, while gently shaking the filter module. Complete this process 4 times.

4. **Shut down procedures:**

a. The operator should perform a short shutdown of the system in thefollowing events:

(1) The raw water level is low.

(2) Product water tanks are full.

(3) There is an interruption in the normal operation cycle.

(4) When the unit will be shutdown for less than 8 hours.

b. The procedures for short shutdown are as follows:

(1) Set the control valves to the "shut down" positions:

(a) Ensure that Backwash valve # 3 is on "Backwash".

(2) Stop the engine as follows:

(a) Let the engine idle for a short period.

(b) Keep the speed regulating lever in stop position until the engine has come to a complete stop.

NOTE: To restart the unit perform startup procedures. Check D.E. cake on filter. If D.E. cake is adequate, start filtering process.

c. The operator should perform a long shutdown of the system in thefollowing events:

(1) To secure the system for more than 8 hours.

(2) Prior to termination of the field exercise.

(3) For extended storage or transportation.

d. Procedures for long shutdown are as follows:

(1) Perform short shutdown.

(2) Clean chemical reservoirs.

(a) Open drain valves on the D.E. and chlorine tank.

(b) Set chemical feed heads to “10”.

(c) Position valves in start up position

(d) Open injectors.

(e) Perform startup procedures on pump. (After suction bring to half throttle)

(f) Run the system for 3 to 5 minutes until clear jet of water comes out of injectors.

(g) Close drain valves, chemical injectors, and set all feeder heads to “0”.

(3) Perform backwash.

(4) Shut the system down.

e. Perform open filter housing washdown:

(1) Drain the filter by removing the drain plug located at the bottom of the filter housing.

(2) Remove the filter clamp.

(3) Remove the upper filter half assembly.

(4) Disconnect the 2 quick disconnect hose fittings that connect the control module to the filter module and plug the upper filter hose.

(5) Set valves to the following positions:

(a) Valve # 1 - Waste

(b) Valve # 2 - On

(c) Valve # 3 - Backwash

(d) Valve # 4 - Filter

(e) Valve # 5 - Close

(f) Valve # 6 - Close

(6) Restart the pump, using water from the best available source.

(7) With pump at full speed, move Waste Outlet valve #2 to - "Off" position.

(8) Using the sampling hose, wash down the complete system.

NOTE: Do not allow the system to operate at maximum power for more than two minutes at a time without water flowing from either the sampling hose or from the waste outlet valve #2, otherwise damage will occur from high pressure.

(9) Let the engine idle for a short period then keep the speed regulating lever in stop position until the engine has come to a complete stop.

5. **After operation checks and services:**

a. Check oil level in crankcase at least once per day. Change every 100 hours of operation along with the oil filter.

b. Check the air filter and cyclone, the air filter should be replaced every 1000 hours of operation or when ever dirty.

c. Replace fuel filter every 2000 hours of operation.

6. **Disassembly and storage:**

a. Drain all hoses and equipment.

b. Clean unit and repack unit.